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Project Title: Southern ocean seasonal net production from satellite, atmosphere, and ocean data sets.

ABSTRACT

A new climatology of monthly air-sea O_2 flux was developed using the net air-sea heat flux as a template for spatial and temporal interpolation of sparse hydrographic data. The climatology improves upon the previous climatology of Najjar and Keeling in the Southern Hemisphere, where the heat-based approach helps to overcome limitations due to sparse data coverage. The climatology is used to make comparisons with productivity derived from CZCS images. The climatology is also used in support of an investigation of the plausible impact of recent global warming on oceanic O_2 inventories.

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The purpose of this project was to construct chemical budgets for dissolved oxygen and inorganic carbon in the surface waters of the Southern Ocean for the purpose of constraining productivity algorithms and improving estimates of air-sea CO_2 exchange. This project resulted in two publications:

(1) Garcia, H.E., Keeling, R.F., On the global oxygen anomaly and air-sea flux, Journal of Geophysical Research, 106, 31155-31166, 2001.

(2) Keeling, R.F., Garcia, H.E. The change in oceanic O_2 inventory associated with recent global warming, Proceedings of the National Academy of Sciences, in press, 2002.

In the first publication, we examine correlations between air-sea O_2 and heat exchanges on seasonal time scales and use these correlations to construct a new O_2 flux climatology. The study relies on hydrographic data for dissolved O_2, salinity and temperature archived as of 1998 at the National Ocean Data Center (NODC), plus additional selective data compilations. It also relies on the air-sea gas exchange formulation of Wanninkhov (1992), and climatological winds and heat fluxes from the European Centre for Medium-Range Weather Forecasting (ECMWF). Although the new climatology is global in extent, the main improvements relative to the previous climatology of Najjar and Keeling (1997,1999), are in the Southern Ocean, where the newer approach helps to overcome difficulties resulting from the sparse data coverage in this region. The improved representation of the Southern Hemisphere O_2 fluxes is evident in comparisons with atmospheric O_2/N_2 data. We used the new climatology to make comparisons with

productivity derived from Coastal Zone Color Scanner (CZCS) images. The new seasonal O_2 flux climatology is archived and available through the JGOFS office.

In the second publication, we build on the results of the first study to estimate the plausible impact of recent global warming the oceanic O_2 inventory (Keeling and Garcia, 2002). The study starts by noting that air-sea heat and O_2 fluxes are correlated over a range of space and time scales, with a ratio of order 5 nmol O_2 J^{-1}. This ratio accounts both for O_2 exchanges driven by solubility changes, as well as for O_2 exchanges linked to stratification-induced changes in ocean biology and mixing. The study then adopts the "null" hypothesis that the same ratio may apply to secular warming over the last few decades due to increasing greenhouse gases. This then implies that the ocean O_2 inventory should have decreased over the last few decades at a rate of around 0.3_10^{14} mol O_2 yr^{-1}, which must have been balanced by an outgassing of O_2 to the atmosphere of the same magnitude. The study points out that O_2 changes of this magnitude would be large enough to impact global carbon budgets based on either (1) changes in atmospheric O_2/N_2 ratio or (2) changes in oceanic dissolved inorganic carbon (DIC). The latter method is impacted because the changes in DIC are typically normalized against dissolved O_2, as a means of filtering variability.

It was originally our intention to employ the seasonal O_2 flux /heat flux correlations as a basis for improving global pCO_2 climatologies. In the third year, however, it became evident that the work required to complete a CO_2 study to the point of publication would have extended beyond the project end-date. Since continued funding beyond this date was not available for Hernan Garcia (the postdoc employed at Scripps for this project), the decision was made to focus on the manuscript revisions and database preparations related to work already in progress, as described above.

REFERENCES

Najjar, R.G. R.F. Keeling. Analysis of the mean annual cycle of the dissolved oxygen anomaly in the world ocean. *Journal of Marine Research* **55**, 117-151, 1997.

Najjar, R.G., R.F. Keeling. The mean annual cycle of the air-sea oxygen flux: a global view, *Global Biogeochemical Cycles*, 14, 573-584, 2000.

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